

REMARKS

Examiner objects to FIG 1 as not having textual labels. Applicants thank the Examiner for a telephone interview to discuss suitable labels to overcome the objection. Textural labels from the description of the embodiment of the invention beginning at page 5 are added to Figure 1 for Examiner's approval. A formal drawing will be filed after allowable subject matter has been identified.

PTO Draftsperson's Patent Drawing Review indicates an objection to FIG 2 for views not labeled separately or properly. A label for the views is added to FIG 2 from the description of the views at page 9. A formal drawing will be filed after allowable subject matter has been identified. No new matter is added by the corrections to the figures, and Examiner is respectfully requested to withdraw the objections.

Examiner objects to the word "comprises" and to spacing errors in the Abstract. A replacement Abstract is submitted conforming to Examiner's requirements. Applicants request Examiner to withdraw the objection.

Examiner objects to claims 7-10 for improperly expressing $^{13}\text{CO}_2$ as ^{13}CO . The claims are amended to correct the error. Applicants request Examiner to withdraw the objection. A similar error appears at page 4 line 3 and is also corrected. The specification consistently refers to isotopes of carbon dioxide. No new matter is added by the amendments.

The expression "[a wavelength of isotope $^{12}\text{CO}_2(\text{nm})$]:[a wavelength of isotope $^{13}\text{CO}_2(\text{nm})$]" is amended in the specification at page 4 line 4 and in the claims to replace the brackets with parentheses. The amendment is made to avoid confusion with the conventional editing use of brackets to indicate cancelled material. No new matter is added by the amendments.

The specification is amended at page 5 line 18 to describe element 2b as a "laser diode driver." The amendment is supported by the description at line 27 of page 5, for example. No new matter is added by the amendment.

The specification is amended at page 9 line 11 to correct a spelling error in the title of the reference publication cited by applicants. No new matter is cited by the amendment.

Claims 1-6 and 11 are rejected under 35 U.S.C. §102(b) as being anticipated by Lee et al. (US 4,990,780). Applicants traverse the rejection to the extent that it can be maintained.

Briefly, applicants' invention relates to a spectroscopic method for analyzing isotope constituents in gas samples using a reference gas having two absorption wavelengths close to the absorption wavelengths of the isotopes. Absorption wavelengths of the reference gas are used to identify absorption wavelengths of the isotopes for analysis. In particular, a semi-conductor laser (LD) emitting infrared energy in a 2000 nm wavelength band is used to obtain the absorption spectra of a gas sample containing an analyte having isotopes. The absorption spectra of a reference gas is also obtained. A positional relationship is determined between the absorption spectra of the reference gas and the isotopes to be analyzed (analyte). Wavelengths of the absorption spectra of the isotopes for analysis are calculated from values for the wavelengths of the reference gas, the values of the driving currents of the LD associated with the wavelengths of the reference gas and the rate of change of the wavelengths of the reference gas with respect to the associated driving currents (page 10 line 18 to page 11 line 12). Having precisely identified absorption wavelengths of the analyte isotopes, the abundance ratios and concentrations of the isotopes are determined by conventional calculations (page 11 line 22 to page 12 line 7). The steps of the method are describe in greater detail at pages 10-12, and an embodiment using hydrogen bromide as a reference gas is described at pages 12-17 of the specification. However, other substances such as water and nitrogen oxide are also suitable reference gases (page 9 line 8-10).

In sharp contrast, Lee et al. disclose a method for analyzing exhaust emissions from internal combustion engines to determine engine oil consumption and fuel consumption. An organic halogen compound, such as dibromooctadecane, is added to the engine oil. The bromo compound is converted to hydrogen bromide during the combustion process and emitted in exhaust gas. The amount of hydrogen bromide in the exhaust gas is measured. Oil consumption is calculated from various exhaust parameters and the measured hydrogen bromide content.

Concurrently, and independently of hydrogen bromide analysis, fuel consumption can be estimated from measuring the carbon dioxide content of the exhaust gases. Lee et al. measure hydrogen bromide content using a tunable diode laser emitting a beam having a wavelength zone of 4000 nm. The frequency range of $2400\text{--}2700\text{ cm}^{-1}$ taught at column 4 lines 20-26 approximately equals 3700-4100 nm. Lee et al. do not describe how carbon dioxide content is measured other than to note that "There are several spectral regions with adequate line spacings between the HBr and CO₂ to effect distinction between the gases and with comparable line intensity values for ease on measurement." Clearly, there is no relationship between the presence of hydrogen bromide in the exhaust gas and measurement of carbon dioxide content. Either or both compounds can be measured independently at the discretion of the analyst.

① The analysis of hydrogen bromide tracer isotopes by the method of Lee et al. is not the same as the use of hydrogen bromide as a reference gas required by applicants' claimed method. The method of Lee et al. applies to gas samples wherein hydrogen bromide is the analyte.^② In the applicants' method, hydrogen bromide (or other reference gas satisfying criteria described in the specification) is simply used as a reference or marker to locate isotope wavelengths of an analyte gas, such as carbon dioxide, for determining abundance ratio and concentration. The criteria for selecting a reference gas is that it have two wavelengths that collate with two wavelengths of the analyte. The method of Lee et al. does not have this requirement as Lee et al. do not rely on a reference gas to locate wavelengths of the analyte gas. Applicants submit that the method of Lee et al. does not anticipate claim 1. Applicants' respectfully request Examiner to withdraw the rejection of claim 1 on this ground. ③

Claims 2-6 are directly or indirectly dependent from claim 1. It is axiomatic that claims depending from an allowable independent claim are likewise allowable. Regarding claim 2, hydrogen bromide is claimed as the reference gas not the analyte. Lee et al. teach a method of analyzing for hydrogen bromide, but do not teach its use as a reference gas. Applicants' respectfully request Examiner to withdraw the rejection of claim 2 on this ground. Regarding claim 3, the method taught by Lee et al. does not use a reference gas to identify carbon dioxide isotopes. Applicants' respectfully request Examiner to withdraw the rejection of claim 3 on this ground. Regarding claims 4-6, Lee et al. disclose a laser diode tunable over a wavelength range ④ ⑤

of 2.5 to 30 microns, or 2,500 to 30,000 nm (column 5 lines 25-28). The claimed wavelength zone of 2,000 nm band is outside of the wavelength range disclosed by Lee et al. for an LD suitable for use in their method. Applicants' respectfully request Examiner to withdraw the rejection of claims 4-6 on this ground. (u) 2500 nm band

Regarding claim 11, Lee et al. teach an analytical wavelength region of about 4000 nm (column 4 line 22) in contrast to the 2000 nm wavelength zone claimed by applicants. Since Lee et al. do not require wavelengths of the absorption spectra of hydrogen bromide to collate with the wavelengths of an analyte gas, there is no teaching that a wavelength of 2000 nm is critical in the Lee et al. method. Simply disclosing a laser diode tunable over a broad range does not provide a teaching that a particular wavelength is critical to performing the claimed method. (1) Also, as explained above, hydrogen bromide is the analyte measured by Lee et al. and is not a reference gas as asserted by Examiner. Applicants' respectfully request Examiner to withdraw the rejection of claim 11 on this ground.

Claims 7-10 are rejected under 35 U.S.C. §103(a) as being unpatentable over Lee et al. (US 4,990,780). Applicants traverse the rejection to the extent that it can be maintained.

Claims 7-10 are dependent claims depending from claims 3-6, respectively. Claims 3-6 depend directly or indirectly from claim 1. The method of claim 1 is not taught or suggested by Lee et al. As explained above, Lee et al. teach a method for directly analyzing a tracer isotopic species such as hydrogen bromide by spectroscopic means, i.e. the tracer isotopic species is the subject of the analysis. Lee et al. do not teach or suggest a reference gas, i.e. an auxiliary gas, to identify the analyte (carbon dioxide isotopes) that is the subject of the analysis. Applicants' method uses a reference gas such as hydrogen bromide to locate absorption lines of the analyte species, e.g. carbon dioxide, in the sample gas. This step provides an important advantage of identifying the analytical absorption lines in a spectrum having a large number of closely spaced absorption lines. See for example FIG.2. Although it may be well known in the art, as asserted by Examiner, to study carbon isotopes in the infrared band, applicants assert that it is not known in the art, and Examiner offers no supporting citation, to use a reference gas to locate the analytical absorption lines among the many closely spaced lines in the carbon isotope spectrum.

The knowledge of one skilled in the art does not overcome the complete absence of a reference gas from the method of Lee et al.. Applicants respectfully assert that claim 1 is not obvious based on the teachings of Lee et al. in view of the knowledge of one skilled in the art. As claims 7-10 depend from claim 1 and incorporate all of the limitations thereof, claims 7-10 are likewise allowable. Applicants' respectfully request Examiner to withdraw the rejection of claim 7-10 on this ground.

Reconsideration and favorable action are respectfully requested. If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, Curtis B. Hamre (Reg. No. 29,165), at (612) 336.4722.

Attached hereto is a marked-up version of the changes made to the specification, claims and abstract by the current Amendment. The attached page is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

Respectfully submitted,

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Dated: 12-10-01

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S/N 09/472,585VERSION WITH MARKINGS TO SHOW CHANGES MADEIn the Specification

Please amend the paragraph beginning at page 3 line 27 and continuing to line 12 page 4 as follows.

Furthermore, the fifth aspect according to the present invention provides the spectroscopic method for analyzing isotopes according to the third or the fourth aspect, wherein said isotopes of carbon dioxide gas as sample gas are $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO] and said $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO] have pairs of the following wavelengths

([a wavelength of isotope $^{12}\text{CO}_2(\text{nm})$]):([a wavelength of isotope $^{13}\text{CO}_2(\text{nm})$])

2054.37	:	2053.96
2044	:	2044.49
2035.34	:	2035.63
2010.18	:	2010.29
2002.51	:	2002.54
1995.99	:	1996.10

and a abundance ratio is measured by an absorbance in accordance with said a respective pair of wavelengths.

Please amend the paragraph beginning at page 5 line 8 as follows.

A preferred embodiment of the present invention will be described hereinafter. A spectroscopic method for analyzing isotopes according to the present invention is carried out by a spectroscopic analysis apparatus using a semiconductor laser shown in figure 1. That is to say, figure 1 is a schematic diagram of a system showing an embodiment of a spectroscopic analysis apparatus using a semiconductor laser according to the present invention. A semiconductor laser beam source 1 oscillating a laser beam having 2000nm-wavelength band is driven by a laser

driver 2. For oscillating a desired and appropriate laser beam, the laser driver 2 comprises a temperature controller 2a for controlling appropriately a temperature of a laser element, a laser diode [2b] (hereinafter, referred to as "LD") driver 2b for providing the laser element with an electric current and driving the same, and a function generator 2c as a frequency modulating means for modulating oscillating frequency of the laser based on frequency modulation. Moreover, these 2a,2b,2c are coupled to a computer 9 for an appropriate operation.

Please amend the paragraph beginning at page 9 line 11 as follows.

Also, t[T]he figure 2 was cited from "High Res[S]olution Transmission Molecular Absorption Data Base" issued by Air Force Geophysics Laboratory of U.S.A. in 1986.

In the Claims

Please amend claims 7-10 as follows:

7.(AMENDED) The spectroscopic method for analyzing isotopes according to claim 3, wherein

said isotopes of carbon dioxide gas as sample gas are $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO]; and

said $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO] have pairs of following wavelengths

([[[a wavelength of isotope $^{12}\text{CO}_2$ (nm)]]]:([[a wavelength of isotope $^{13}\text{CO}_2$ (nm)]]])

2054.37	:	2053.96
2044	:	2044.49
2035.34	:	2035.63
2010.18	:	2010.29
2002.51	:	2002.54
1995.99	:	1996.10

and a abundance ratio is measured by an absorbance in accordance with said a respective pair of wavelengths.

8.(AMENDED) The spectroscopic method for analyzing isotopes according to claim 4, wherein

said isotopes of carbon dioxide gas as sample gas are $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO]; and

said $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO] have pairs of following wavelengths

([a wavelength of isotope $^{12}\text{CO}_2(\text{nm})$]):([a wavelength of isotope $^{13}\text{CO}_2(\text{nm})$])

2054.37	:	2053.96
2044	:	2044.49
2035.34	:	2035.63
2010.18	:	2010.29
2002.51	:	2002.54
1995.99	:	1996.10

and a abundance ratio is measured by an absorbance in accordance with said a respective pair of wavelengths.

9.(AMENDED) The spectroscopic method for analysing isotopes according to claim 5, wherein

said isotopes of carbon dioxide gas as sample gas are $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO]; and

said $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO] have pairs of following wavelengths

([a wavelength of isotope $^{12}\text{CO}_2(\text{nm})$]):([a wavelength of isotope $^{13}\text{CO}_2(\text{nm})$])

2054.37	:	2053.96
2044	:	2044.49
2035.34	:	2035.63
2010.18	:	2010.29
2002.51	:	2002.54
1995.99	:	1996.10

and a abundance ratio is measured by an absorbance in accordance with said a respective pair of wavelengths.

10.(AMENDED) The spectroscopic method for analyzing isotopes according to claim 6, wherein

said isotopes of carbon dioxide gas as sample gas are $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO]; and

said $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$ [^{13}CO] have pairs of following wavelengths

(([]a wavelength of isotope $^{12}\text{CO}_2(\text{nm})$)):([[]a wavelength of isotope $^{13}\text{CO}_2(\text{nm})$))

2054.37	:	2053.96
2044	:	2044.49
2035.34	:	2035.63
2010.18	:	2010.29
2002.51	:	2002.54
1995.99	:	1996.10

and a abundance ratio is measured by an absorbance in accordance with said a respective pair of wavelengths.

In the Abstract

Please delete the Abstract and rewrite as follows.

[The present invention provides a spectroscopic method for analysing isotopes which makes it possible to simplify a system for measurement and to identify isotopes with high accuracy and sensitivity and to carry out a quantitative analysis. The spectroscopic method for analysing isotopes by using a semiconductor laser according to the present invention comprises the steps of using a semiconductor laser beam having 2000 nm-wavelength band as a beam source of said wavelengths of said absorption spectra; and using a reference gas for identification of the isotopes, where the gas contains collating components having two wavelengths(W1,W2) of well-known absorption spectra in wavelength band close to the wavelengths(w1,w2) of the absorption spectra of the isotopes.] The present invention provides a spectroscopic method for analyzing isotopes which makes it possible to simplify a system for measurement and to identify isotopes with high accuracy and sensitivity and to carry out a quantitative analysis. The

spectroscopic method for analyzing isotopes uses a semiconductor laser beam having as a wavelength zone a 2000 nm-wavelength band as a beam source of wavelengths of the absorption spectra of the isotopes. A reference gas is used for identification of the isotopes where the gas contains collating components having two wavelengths (W1, W2) of well known absorption spectra in wavelength bands close to the wavelengths (w1, w2) of the absorption spectra of the isotopes.

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